Innovative Vehicle Electronics Systems

DC750 DC Motor Controller User Manual

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Introduction

Thank you for purchasing the Synkromotive DC750 controller. This controller has been designed to be one of the most versatile DC motor controllers on the market. It can be used in all sizes of on-road and off-road electric vehicles utilizing systems from 24~192 volts. Although the controller is optimized to regularly provide 750 amp accelerations the controller is fully adjustable allowing short duration current limits up to 900 amps.

The DC750 has a patented design feature which reduces power loss; it switches faster and more efficiently thereby producing less heat. However some cooling is still required. On a vehicle less weight means better performance and more range so the DC750 needed a cooling scheme that was simple and light weight. In a liquid cooled system the coolant must move hot liquid from the heat source to a radiator which is either fan cooled or exposed to a large volume of cold air. Ultimately this means even liquid cooling still requires the excess heat transfer to the air. So rather than add the extra weight and plumbing required simply to move the heat to a different location to be fan cooled the DC750 cuts to the chase and uses an aggressive forced air design to effectively transfer excess heat directly to the air.

The DC750 is high side topology which offers reduced motor and brush corrosion risk over less expensive controllers. Also the power stage is fully isolated from the control wiring thereby reducing shock hazard. The CAN communication system is also fully isolated to ensure noise free real time communication. This feature rarely exists on other controllers. The case is also fully isolated from all internal circuitry making it easier to install without adding additional mounting insulators.

Another feature that sets the DC750 apart is the user interface. Advanced microprocessor technology allows reprogramming or recalibration of the system while installed, via the Synkromotive interface (SMI). The Synkromotive interface also allows the user to view data in real time, in both text and graphical formats. In addition, the on-board flash memory provides a nonvolatile backup of all system parameters and settings.

The DC750 has built in +12 volt output contactor coil drivers that allow the user to confugure the controller to work in the various common electric vehicle configurations. Unlike software only systems in some cars all contactor outputs can be “manually overridden” and disabled by simply turning off the “key” and thereby removing power to contactors. Also a built pre-charging system is in place to extend the life of the main contactor as well as provides a pre-power up safety check.

These are a just a few of the many design details that went into the Synkromotive DC750 motor controller.

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Integrated Safety Features

The DC750 contains an intelligent, multiple redundant failsafe system to provide a high degree of safety. The vehicle will shut down on any fault as a precaution.

Safe Start:

The start sequence begins when the ignition switch is turned on. Upon every power up, the DC750 tests for shorts and looks at various internal and external control points, such as voltages and temperatures. The throttle must be in a zero state before the drive mode is enabled to prevent unintended movement. Low traction pack voltage also prevents vehicle operation.

Contactor Control:

The DC750 will activate the contactor when the system successfully completes the safe start sequence. The contactor will remain enabled unless there is a critical fault or if the ignition switch is turned off. The contactor drivers and the pre-charge circuit are all built into the DC750, eliminating the need for any external accessories on the contactor. In addition the contactor control is powered by the key switch thereby providing a manual override disconnect in the event of a runaway condition.

Open Throttle Input:

The DC750 will fault if the throttle signal goes out of range due to faulty wiring or hardware. This also is to prevent a runaway condition.

Priority Braking:

The DC750 assigns priority to the brake in the event that both the brake and throttle are applied simultaneously.

Direction Change Lockout:

The DC750 will not allow the vehicle direction to be changed via a reversing contactor unless the vehicle has come to a full stop and the throttle is at zero. Only then will the DC750 enable the reversing contactor.

Reverse Power Limit:

The DC750 allows for separate speed when in reverse which is useful with vehicles not using a mechanically reversing transmission.

Temperature Monitoring:

The DC750 will limit the current output of the controller in a linear fashion as the internal temperature rises above the normal safe level.

Battery Voltage Monitoring:

The DC750 will limit the current output of the controller when the traction pack voltage is low.

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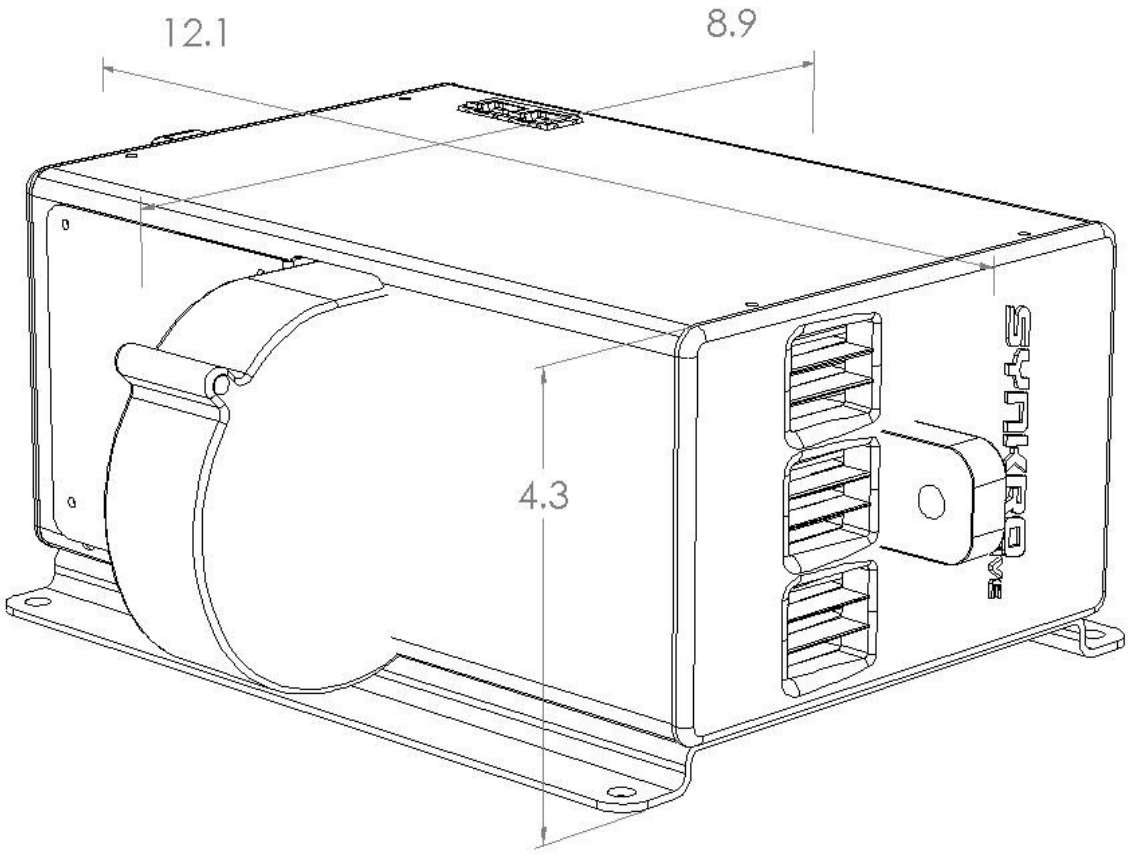
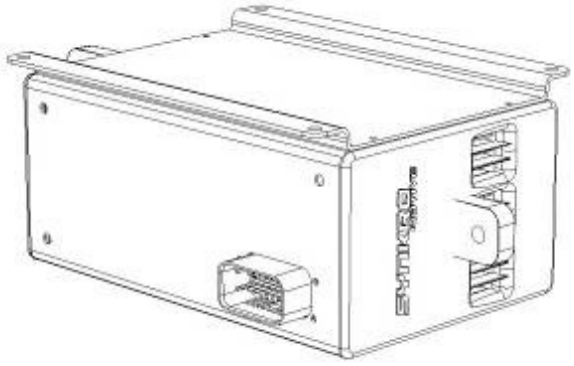
Physical Installation

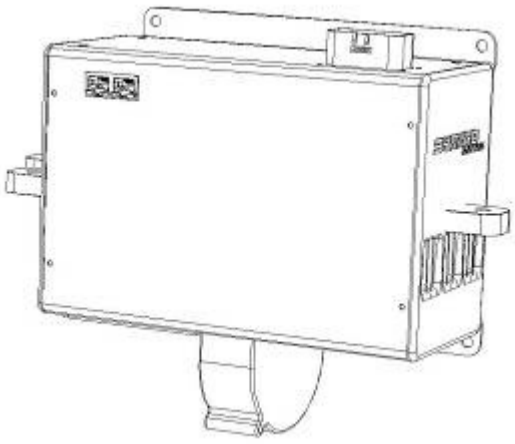
The DC750 is best installed in one of 3 typical orientations shown below. The installation location chosen should provide adequate service access and must provide a continuous supply of fresh air with at least 4” of clearance in front of the integrated fan.



Face up



Face down under



Face out on Firewall

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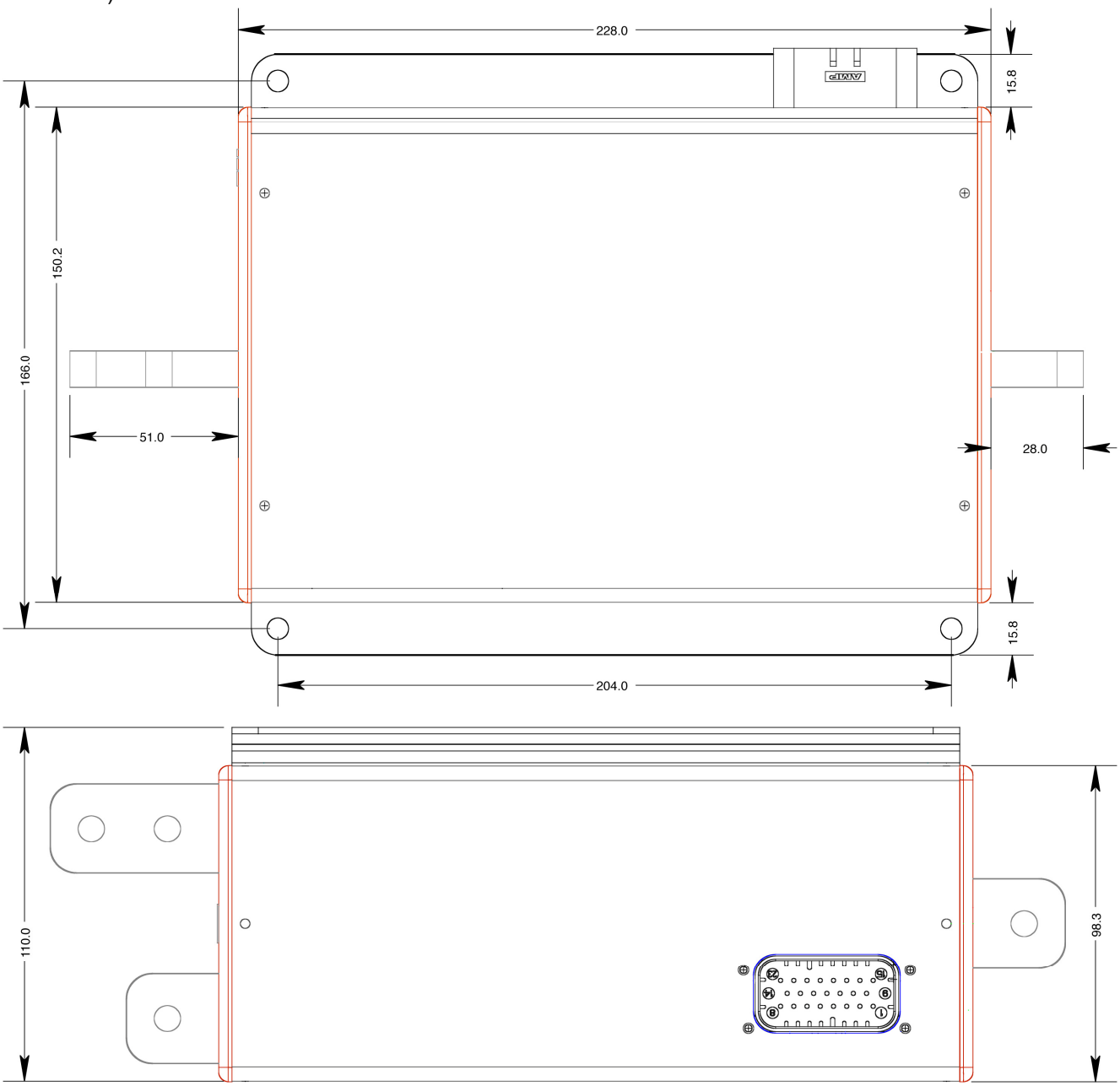
Physical Dimensions in Millimeters (Base Flange Mounting Holes Use ¼” or M6 Hardware):



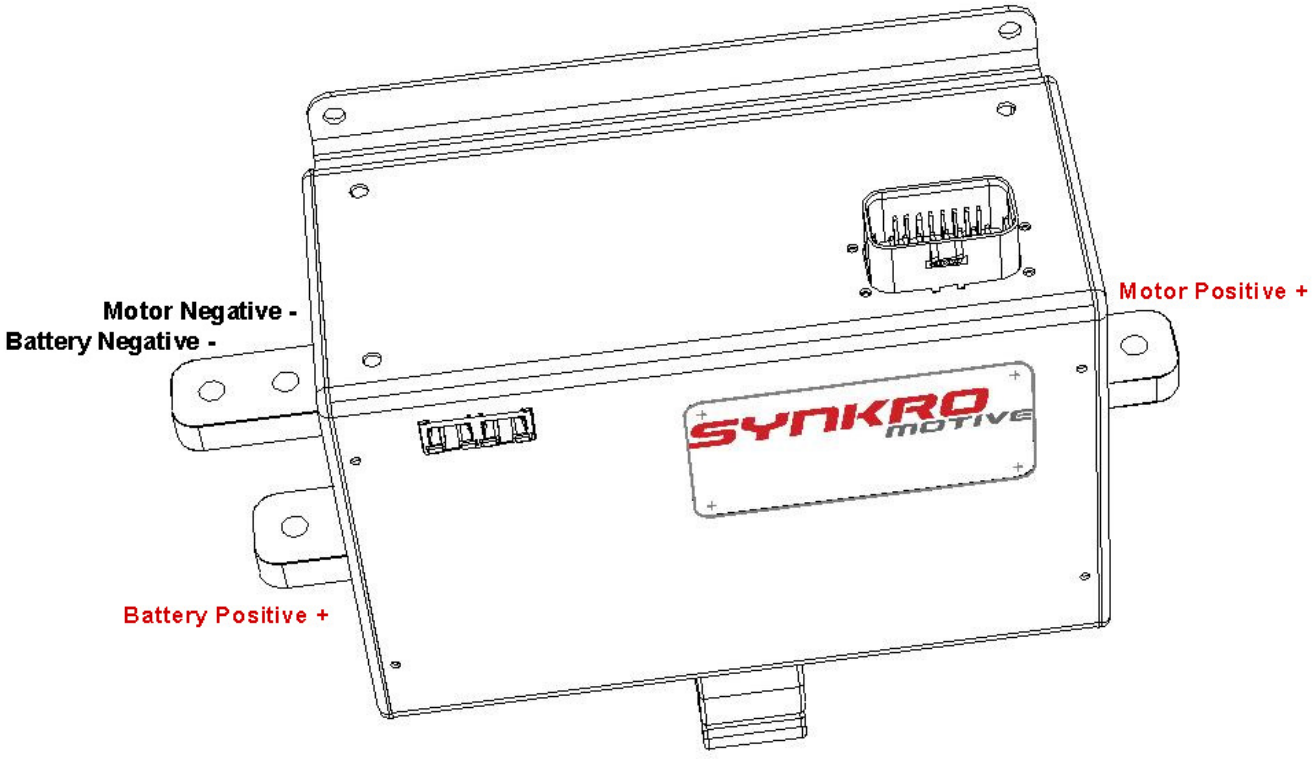
High Voltage (Traction Pack) Wiring

Using a suitable voltage meter, ensure that the traction pack voltage source is disconnected prior to making any connections. Always use insulated tools and gloves while working with high voltage connections.

When routing the cables, it is advised to keep the motor leads as short as possible to minimize electrical noise and power losses. Always run high voltage cables parallel with other high voltage cables. Avoid crossing high voltage cables or attaching control wiring to the power wiring. Always protect the cables against damage from fraying by keeping them away from any sharp surfaces and by using bushings at any penetration.

The holes provided in the buss bars are designed for 5/16” or M8 hardware. Each hole is designed for only one lug connection. Always install the lug with the flat side against the buss bar for maximum surface contact. Use a stainless steel nut and bolt combination with a split lock washer and provide enough torque to make a lasting connection, but take care not to over tighten. Always use a backup wrench when tightening these bolts to keep any stress off of the buss bars.

The DC750’s high side design allows for both motor negative and battery negative to share the same connection post although bolt holes for each are provided as shown below.



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Warning: Motor Positive must always connect inline with post, not at a right angle.

Warning: do not block the exhaust vents. Although not required, bolting lugs on top of the controller's power posts can help avoid blocking vents.

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Connector Wiring Overview

External control wiring connections are made at the 23 position AMPSEAL connector located on the side of the DC750. A prewired assembly of un-terminated leads is provided with the DC750 to assist in the final wiring. The minimum required wiring is noted in ***bold***; all other wiring is recommended but is not required to enter drive mode.

The connector pin functions are as follows:

Speed Sensor Negative	(-)
Sensor 3	+12v Input
Sensor 2	+12v Input
Vehicle Ground	***(-)***
Vehicle Ground	(-)
Contactor Return	(-)
Contactor Return	(-)
Indicator	+12v Output
Accelerator Return	***(-)***
Sensor Supply	+12v Output
Forward Switch	+12v Input
Reverse Switch	+12v Input
Charge Control	+12v Input
Constant Power	***+12v Input***
Reverse Contactor	+12v Output
Battery Pack Positive	***0~200v Input***
Accelerator Supply	***+5v Output***
Speed Sensor 1	+12v Input
Accelerator Input	***0~5v Input***
Brake Switch	+12v Input
Ignition On	***+12v Input***
Main Contactor	***+12v Output***
Forward Contactor	+12v Output

The Synkromotive Controller Harness wires are typically colored based on their type: (input, output, negative, etc.)

When you start your installation it is helpful to separate out and group the 3 Accelerator wires (#9, #17, and #19). Then group the 3 wires to the main contactor (#22, #6, and #16). Next group the 3 speed sensor wires (#10, #18, #1). This leaves the vehicle interface wires (brake, reverse, ignition, etc) easier to sort through.

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Contactors and Safety

There are numerous other features and dependencies that have designed into the DC750 that ensure safe seamless operation.

The controller must be wired so that it controls the contactors. It is able to able to protect itself against reverse polarity and other types of damage when it controls the contactors. No safety is compromised since you can still override the DC750's contactor engagement by killing power to the key input. Without allowing the DC750 to control the contactors, the programming will detect the wiring error and not allow operation.

Multiple redundant safeties are built in to the contactor controls. For example the ignition key inherently overrides the DC750 in hardware. You simply turn off the key and the contactors are no longer powered. The only manual contactor override you will need is the ignition key which by design is the single source of power for all the contactor outputs. In addition all contactor outputs are high side signals so if a control wire is shorted to ground such as in an installation error or an unusual fender bender where a contactor wire is shorted to chassis, the contactor will OPEN not CLOSE unlike other brands of controllers. Also for easing installation the clamping diodes for the contactor coils are prewired inside the DC750 so there is no need to add external diodes at the contactor coils.

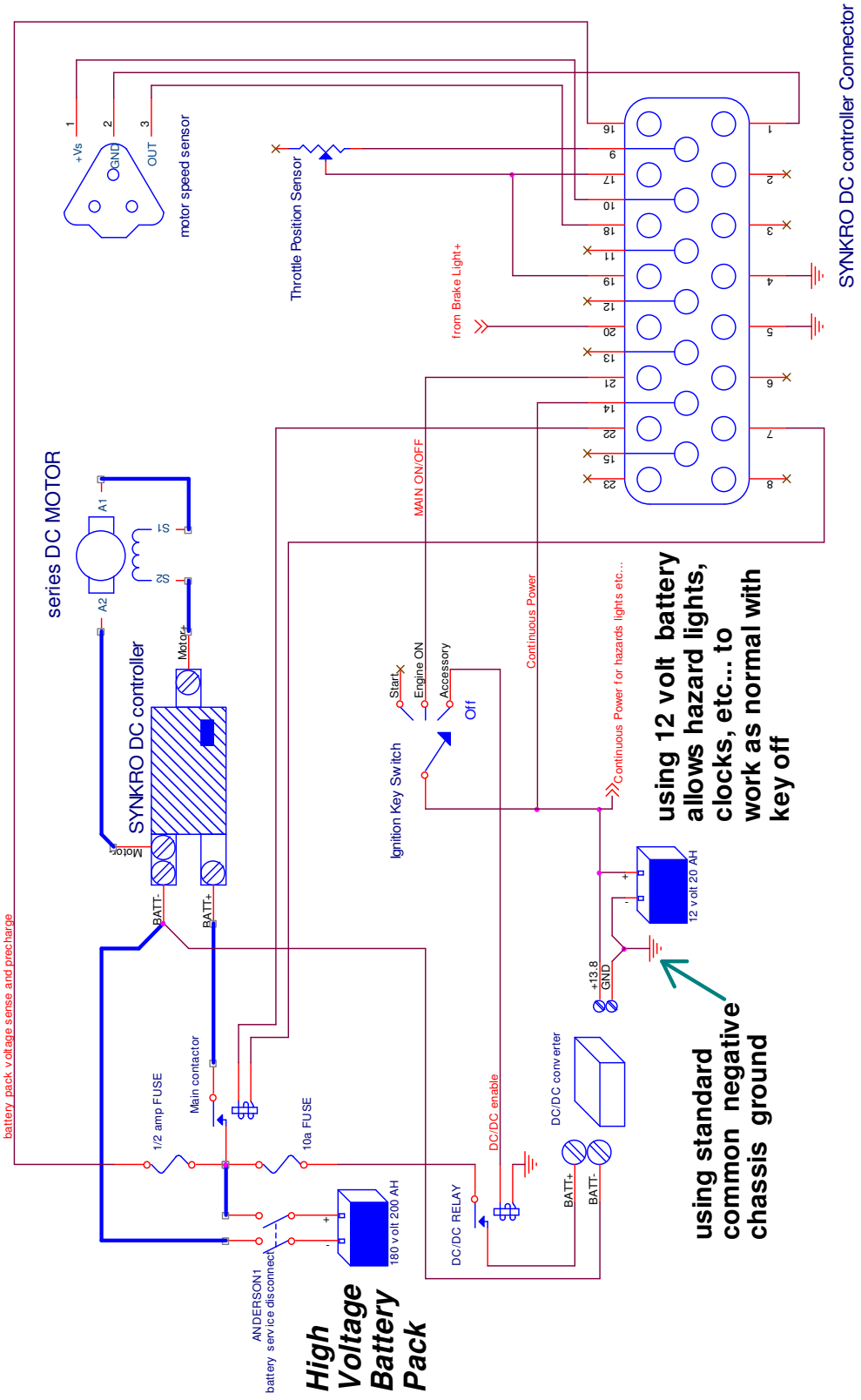
Other safety controls include not allowing reversing contactors to engage when excessive current still exists in the motor after a throttle release. This feature both extends reversing contactor life and controller life. If you are using reversing contactors then it is important for both the reversing and main contactors be controlled by the DC750 to perform these functions.

An optional negative battery contactor and any other pack contactors are best implemented by simply wiring them to the ignition key. Wiring a negative contactor to the DC750’s main contactor output will not allow the DC750s pre-charging function to work properly. The DC750s pre-charging feature both extends main contactor life and improves the DC750’s longevity all while performing various internal safety tests. ONLY upon a successful pre-charging will the DC750 engage the main contactor.

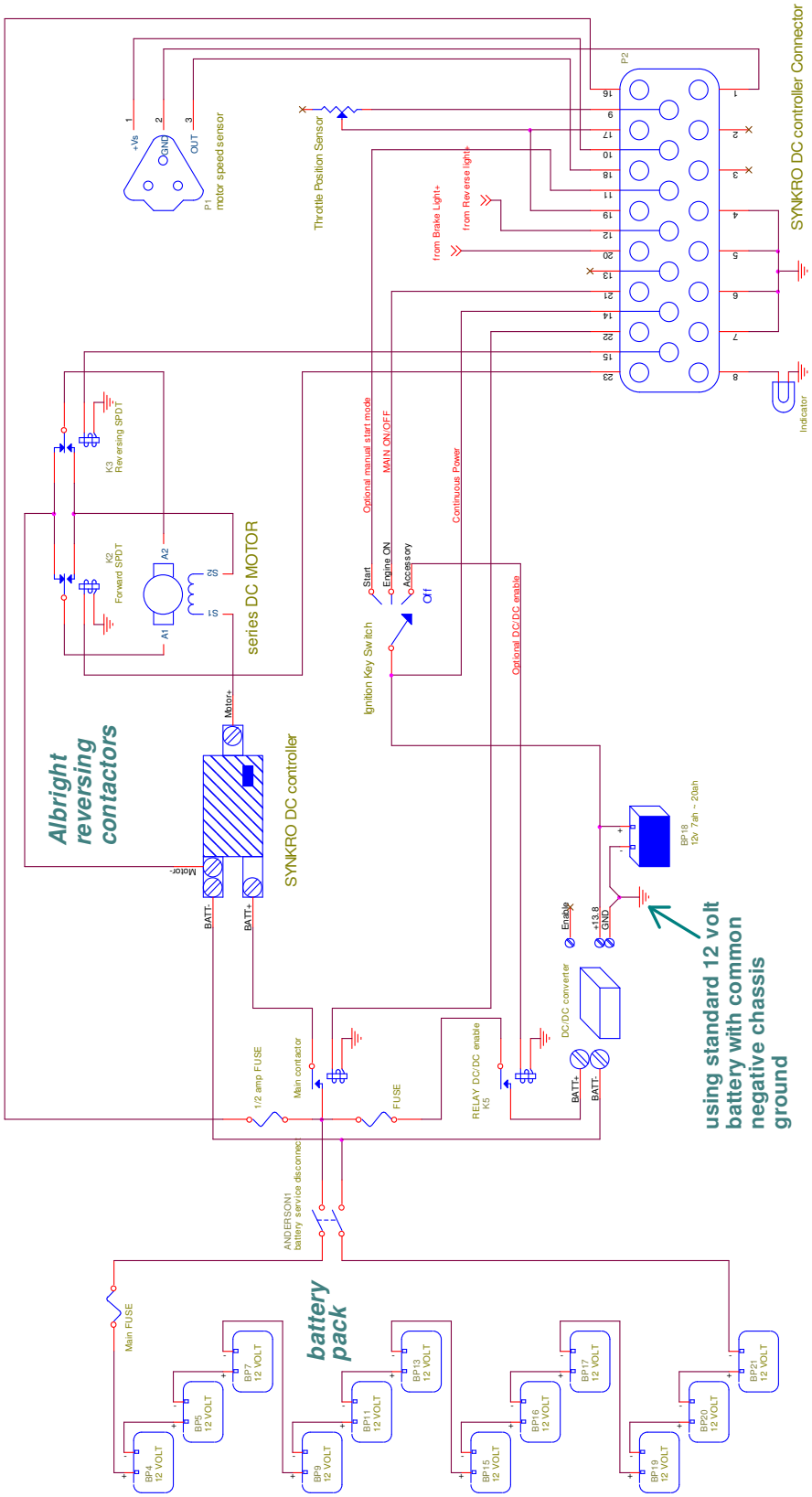
Wiring per this manual will provide the highest level of safety while providing the best performance and longevity of all components including the contactors and motor. If not wired correctly the DC750 may not operate or fault frequently.

You will find it helpful to use the Synkromotive Graphical User Interface when initially powering up the vehicle; all connection faults are viewable in real time and can alert you to the wiring errors much quicker.

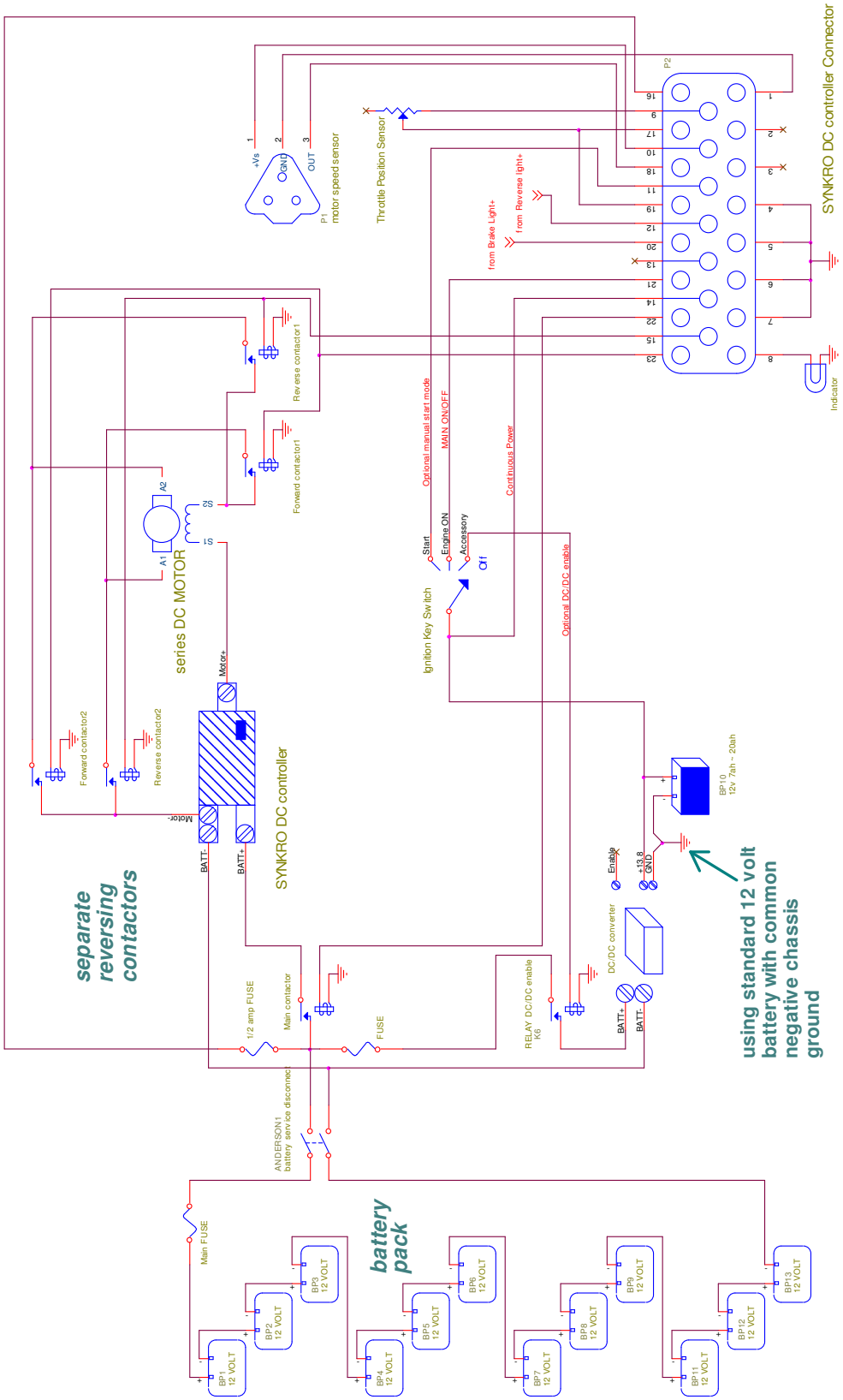
Basic Wiring



Single Reversing Contactor Wiring

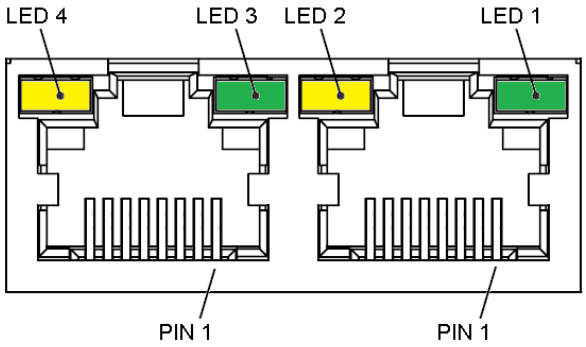


Multiple Reversing Contactor Wiring



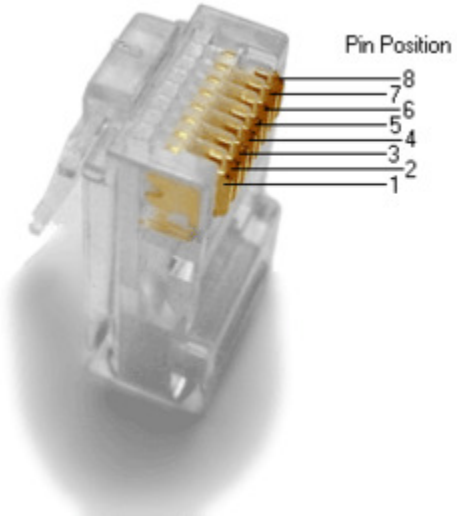
Synkromotive CAN communication

The dual RJ45 port on Synkromotive devices is provided so that daisy chaining multiple devices together is more convenient. The two ports are electrically paralleled therefore identical in use except for LED indicator functions.



At the time of this writing only the center 4 conductors are used as follows:

RJ45 pin	Function
6	+5 volt
5	CANL
4	CANH
3	GND



Using an off the shelf networking cable works best to connect Synkromotive devices. Do not use less common crossover cables. Crossover cables will short out the 5 volt supply and reverse the CANH and CANL lines.

The CAN ports at this time are fully isolated from both the 12 volt auxiliary power and the traction power supplies.

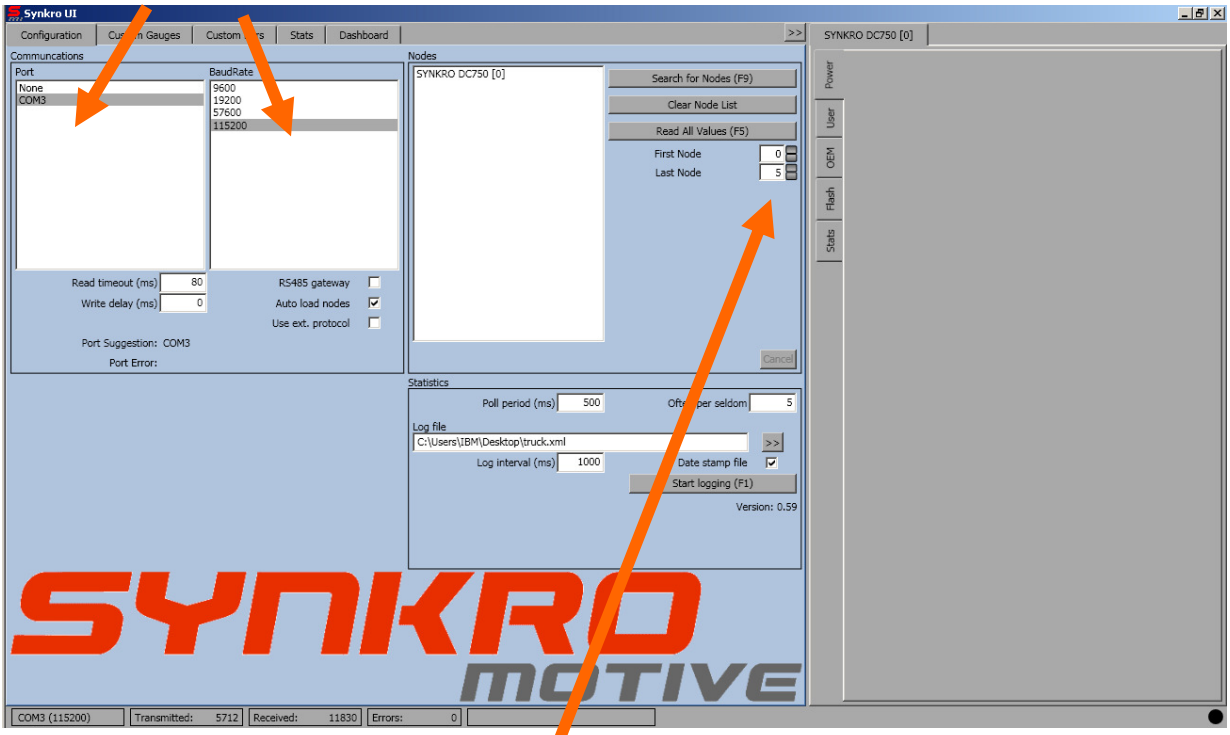
Using the Synkromotive Graphical User Interface (SMI)

The DC750 is configured and calibrated using the SMI software application. A PC or emulated PC running Windows XP or newer and an available USB port are required for this application to run. The executable is downloadable at http://www.synkromotive.com.

You may communicate with the controller without installing it in vehicle by plugging in the harness with +12 volt applied to leads #21 and #14 with ground (-) at lead #4. This is recommended when you first get your controller if you are not familiar with it. The controller can aid installation by indicating connections errors with this interface.

Main Panel / Configuration Tab:

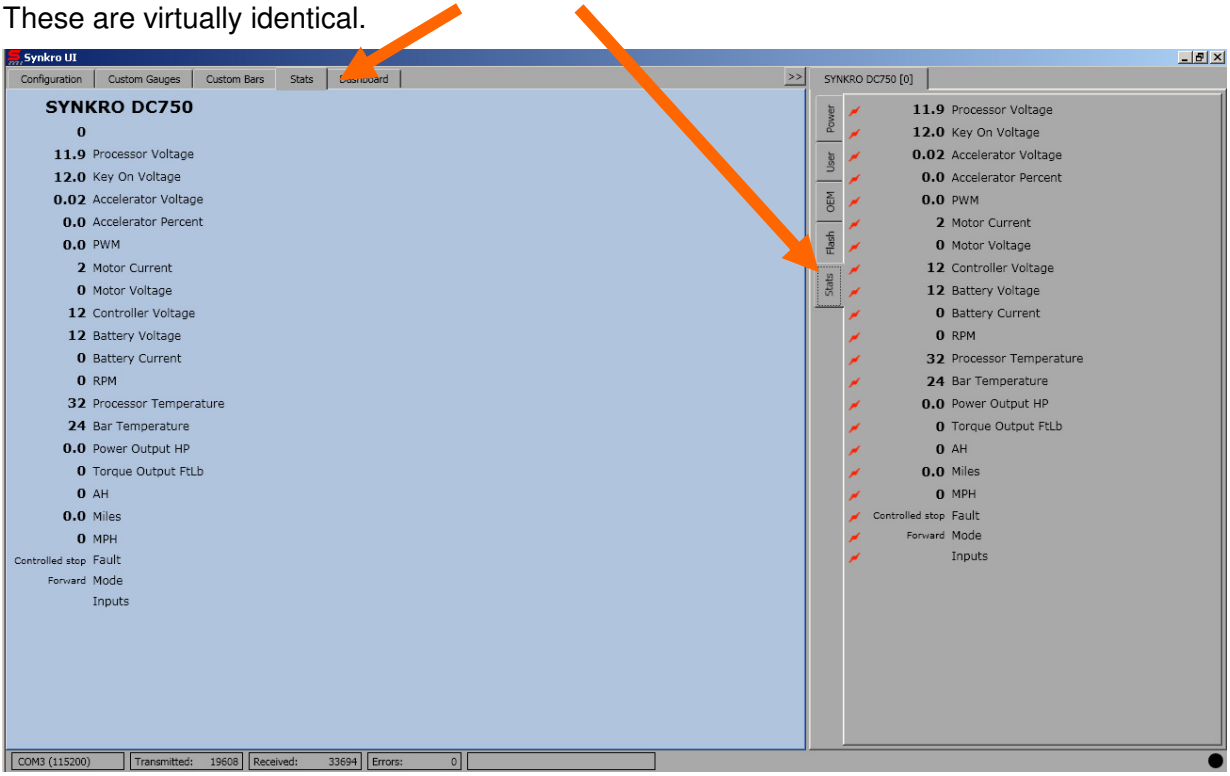
Plug in the USB cable before running the application. The application will default to the most likely COM port. If multiple ports are offered select the suggested port. Then choose “115200” in the selection box under “Communications”/”Baud Rate”.



The software should find the motor controller and load the parameters, after which the controller name will be displayed followed by its node number in brackets. Typically the default node is 0 or 15.

Main Panel / Stats Tab and DC Controller / Stats Tab:

These are virtually identical.



Near instantaneous values are displayed on these. It is useful to display the “Main Panel / Stats Tab” when setting user values on the “DC Controller / User Tab”.

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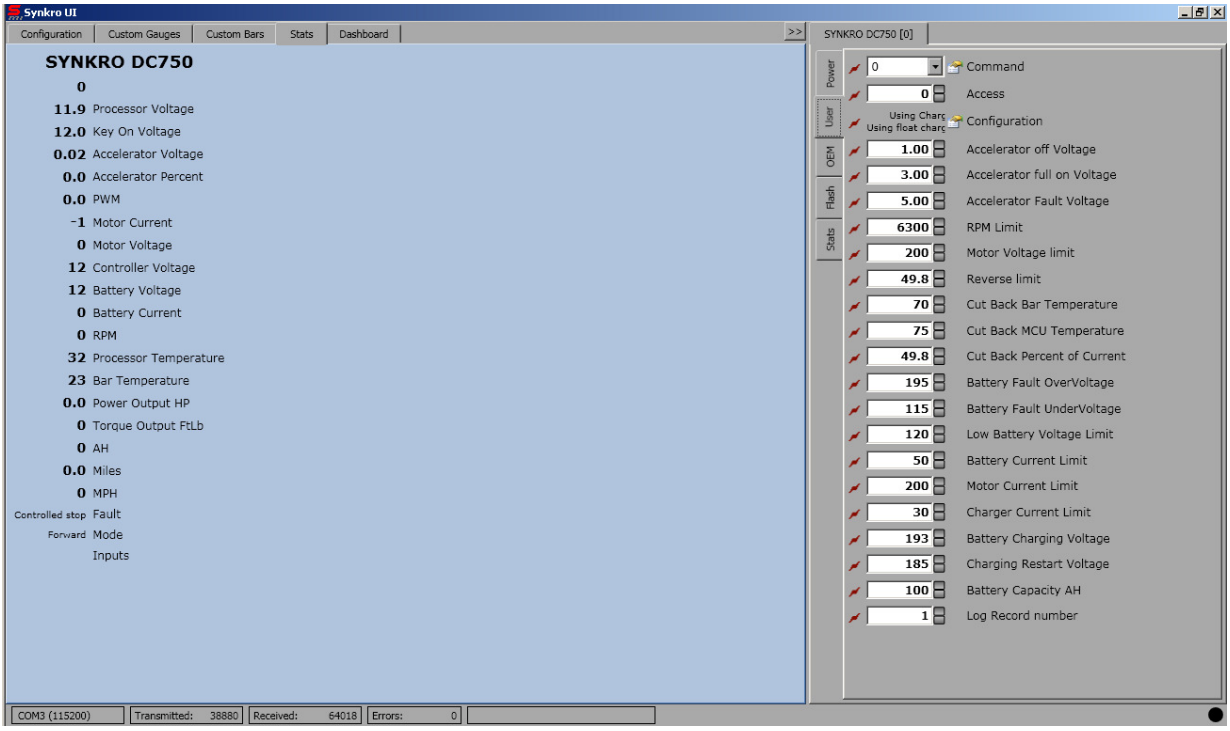
DC Controller / User Tab:

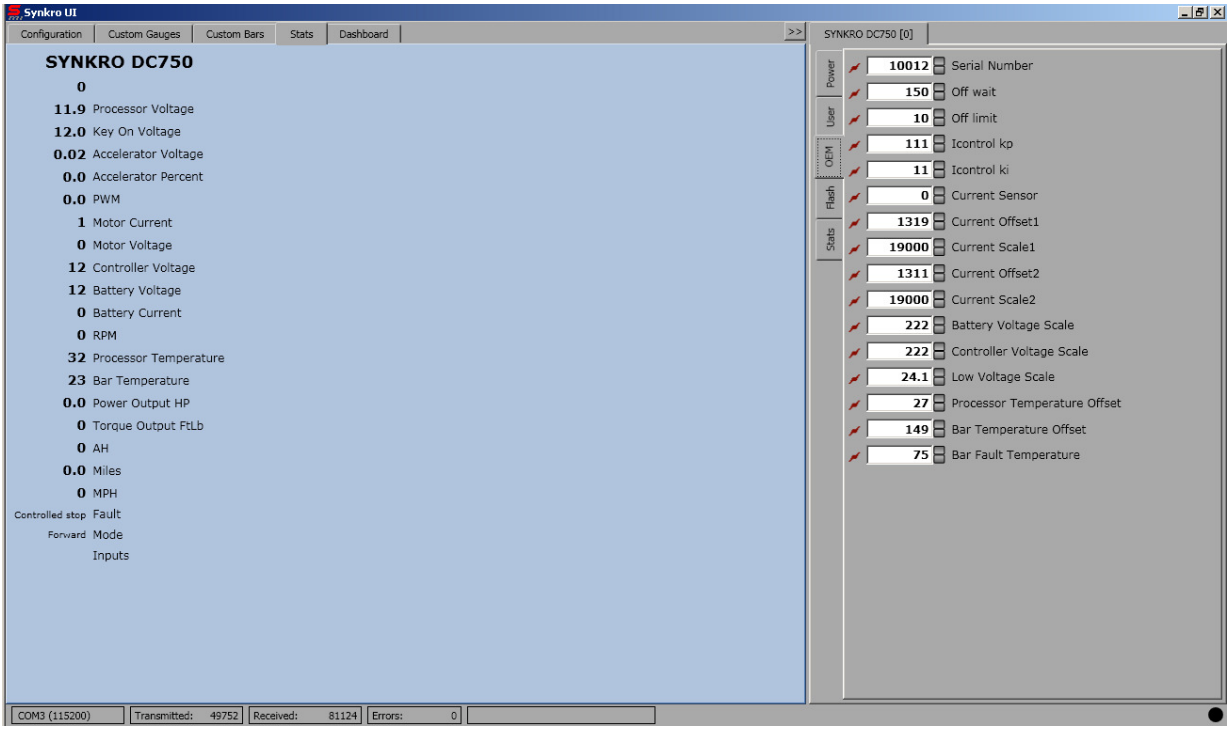


These user accessible settings are internally limited so that they will cause no damage to your controller if you set a value too high or low. Although you may damage your motor or batteries if values are not well selected.

If for example you are using 48 lithium iron phosphate cells, set the battery voltage limit at 130v (= 48 cells x 2.7v per cell). (You will need to check your actual battery specs.)

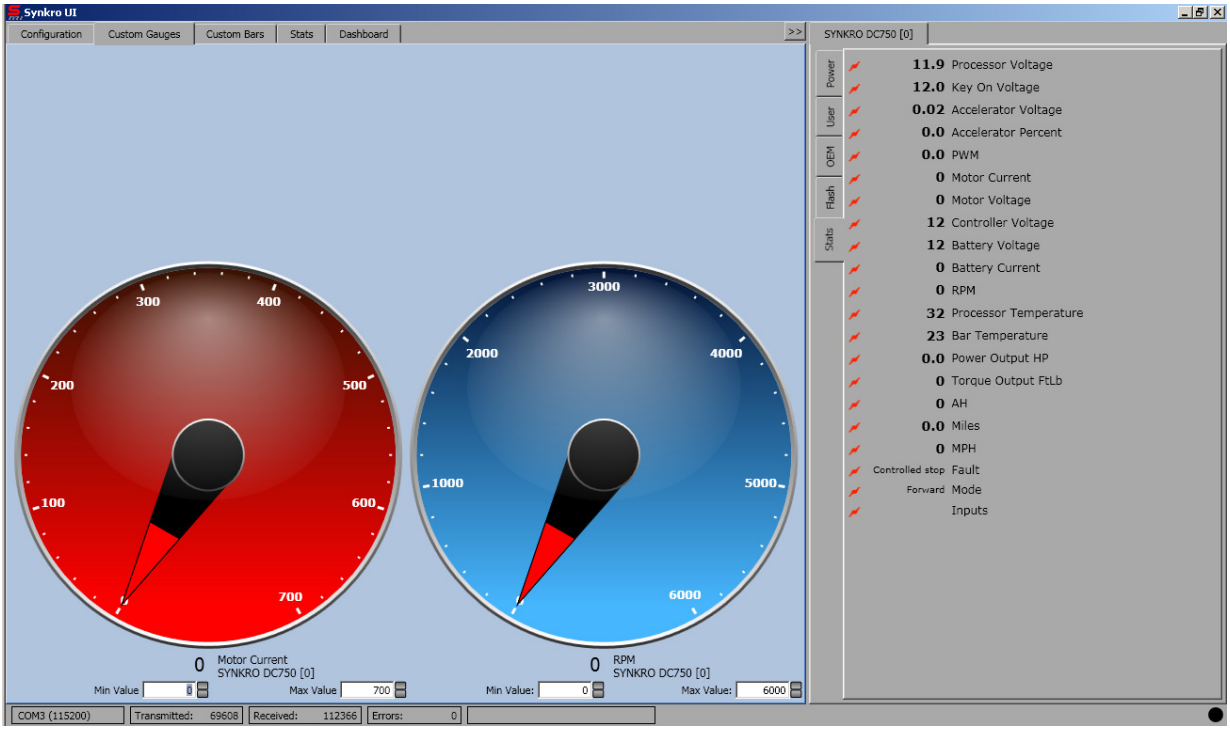
Set the SYNKRO controller for lower motor current for increased range. Also shifting gears will minimize both battery and motor current to extend range and motor life.

DC Controller / OEM Tab:



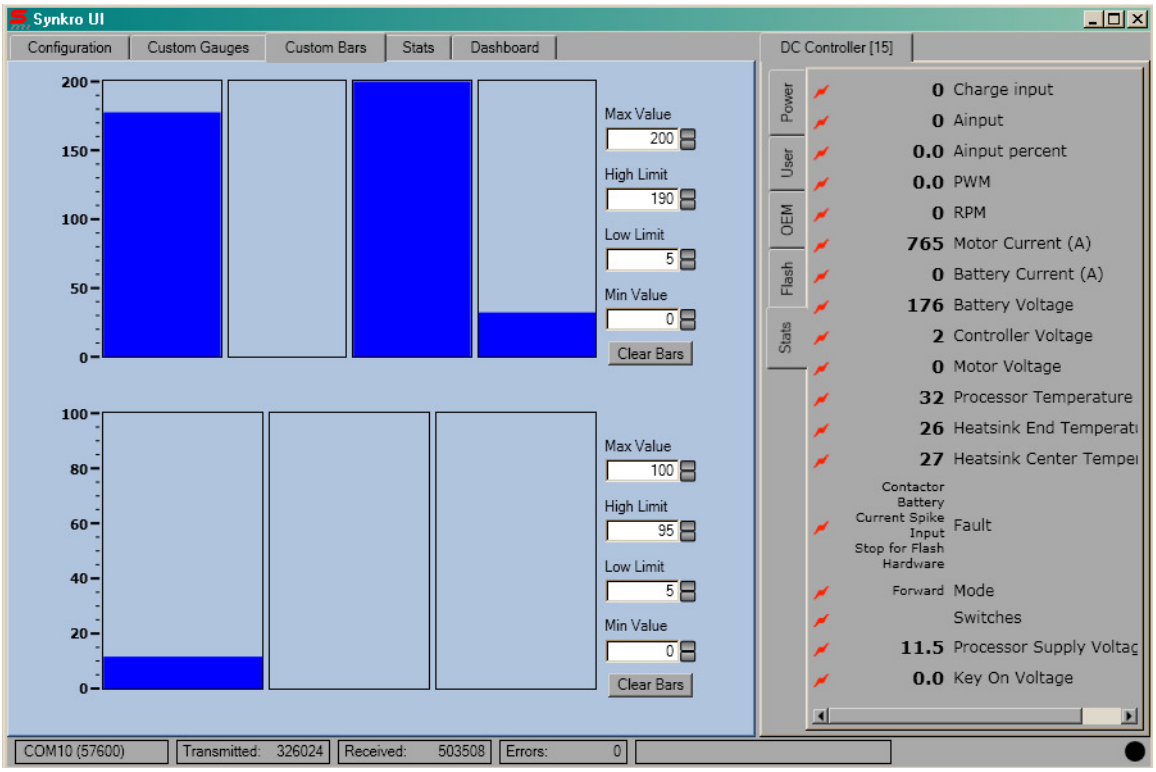
These values are internal calibration values. Do not change any of the values on this page unless directed by Synkromotive. Privilege controls in controller firmware limit inadvertent end user altering of these values.

Main Panel / Custom Gauges Tab:



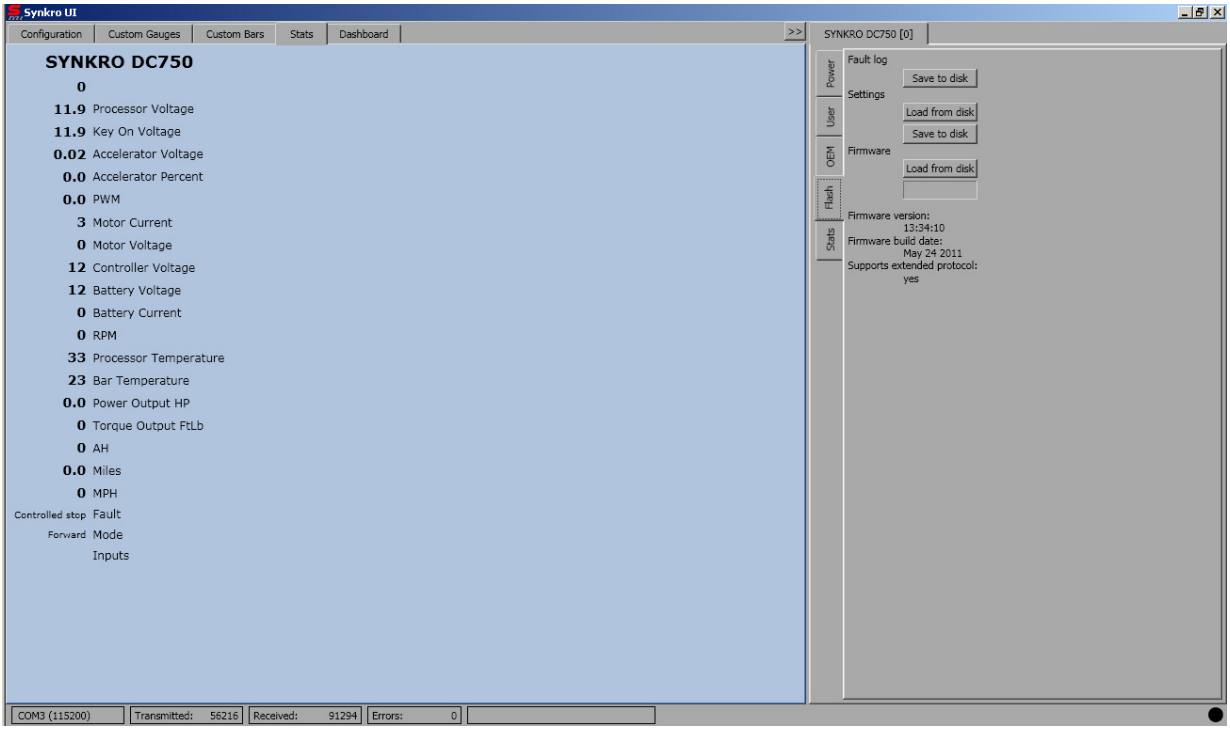
To create custom gauges, navigate to the “Stats” tab on the right. Drag and drop the name of the value to be converted into a gauge over to the gauge on the left side that is to be converted. After it is converted, the scale of the gauge is set with the “Min Value” and the “Max Value” entry boxes.

Main Panel / Custom Bars Tab:



Custom bars are created in a very similar way to custom gauges. Any number of custom bars may be added to the display. Click on “Clear Bars” to delete all custom created bars and return to the default display.

DC Controller / Flash Tab:



Any changed settings can be loaded or saved to the flash memory or to the PC from this page. Saving settings to the flash memory (“Save to Flash”) provides a nonvolatile backup that can be reloaded (“Load from Flash”) at any time as a default setting. Once stable settings are determined, they should be saved to the flash memory and to the PC.

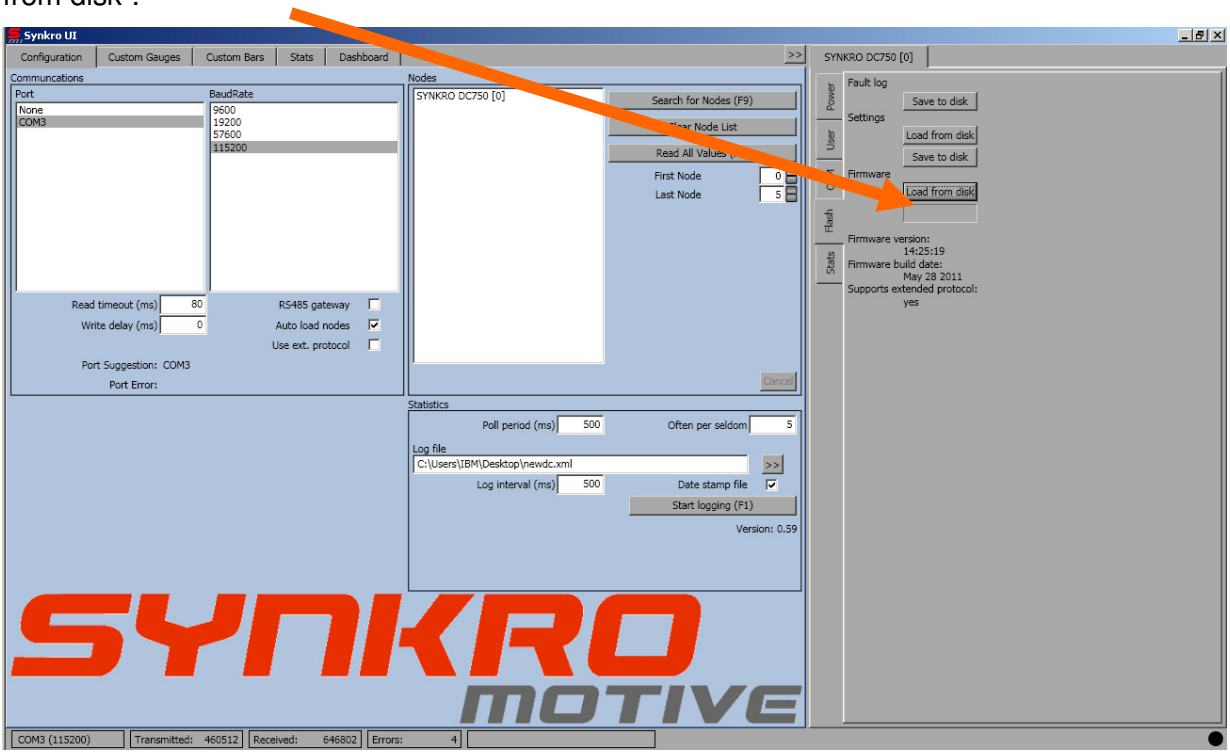
You can save your preferred settings to disk on the flash tab of SMI. This allows you to quickly setup new or replacement controllers on production vehicles etc. Save your settings prior to updating firmware. This is done by clicking on "save settings" under "command" drop down menu on "user tab".

And always wait for communication to stabilize between steps.

Firmware update:

If you receive a firmware update file from Synkromotive you may update the controller's firmware as follows:

While communicating with the controller but with key off, on "Flash" tab click "Firmware" "load from disk".



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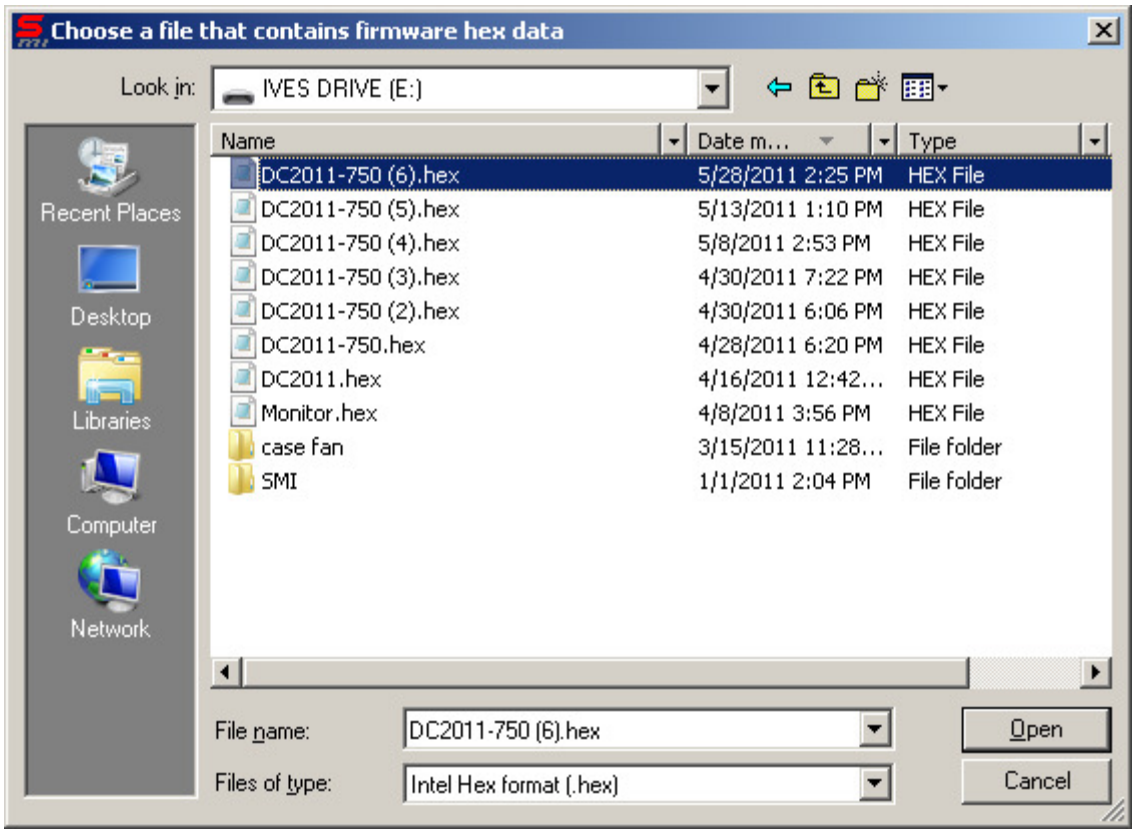
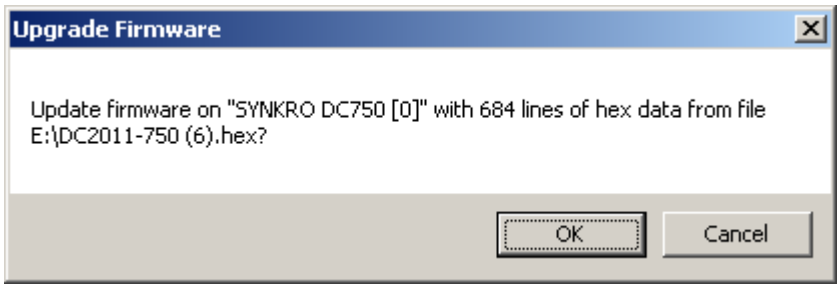
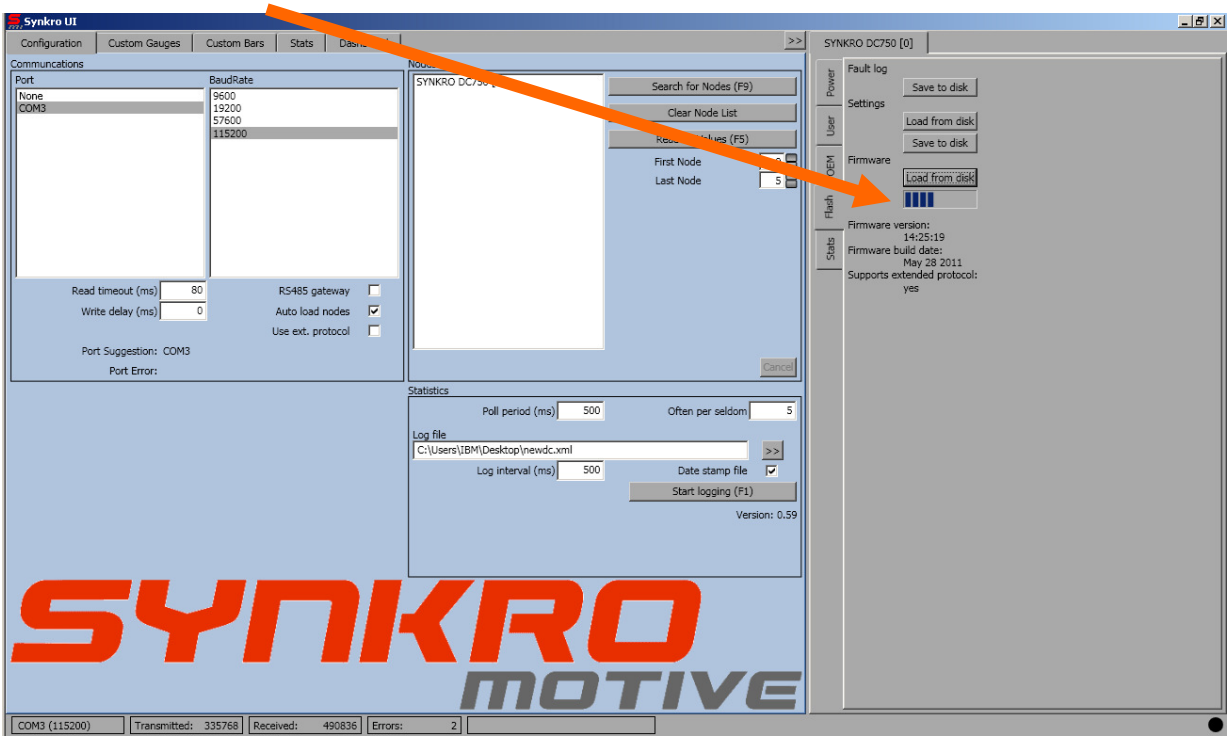
Navigate to the .hex file provided by Synkromotive.



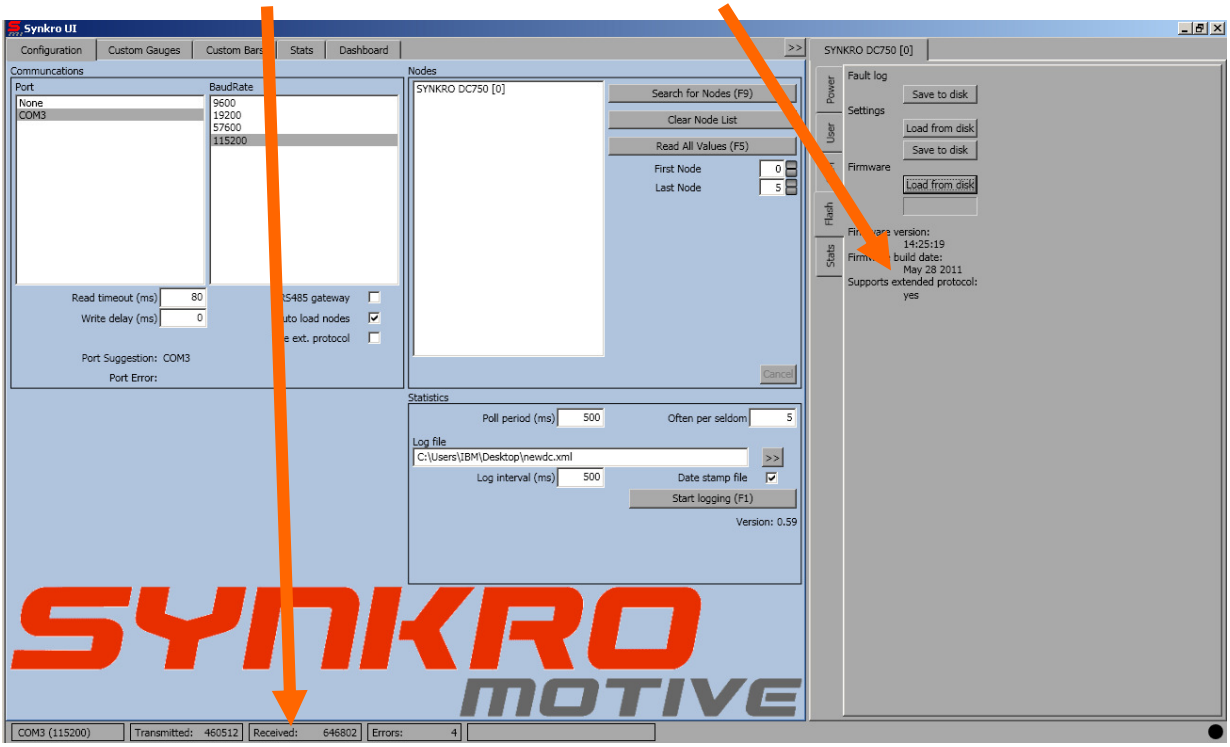
Confirm your selection if appropriate.



Wait while progress bars indicate software update.

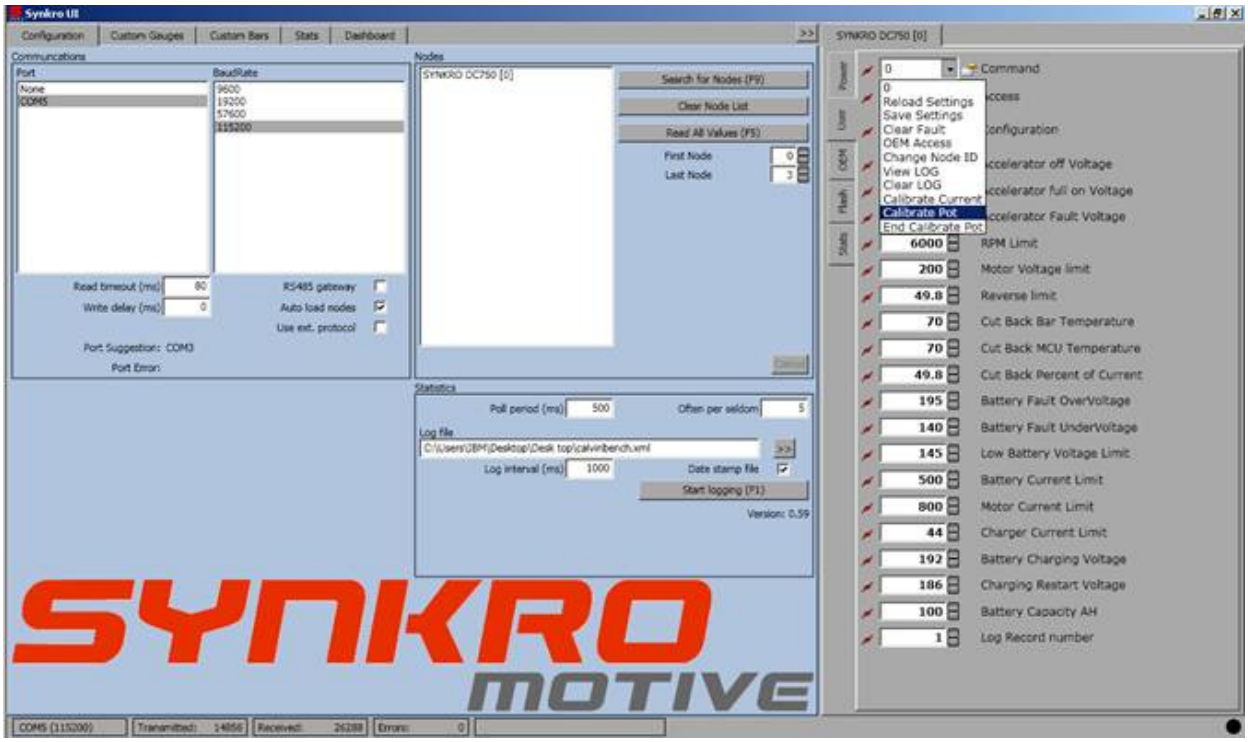


Wait for communication to normalize. The date of the code should be listed here.



Automated Throttle Pot Calibration Process

With **key off** but the controller powered and fully installed, connect with the SMI interface and go to the **user tab** and from the **command** drop down menu select **calibrate pot**.



Next, floor accelerator pedal and release; finish by selecting **End calibrate pot** from drop down menu.

Now when you turn on the **key on**, flooring the accelerator pedal will target 100% of your desired motor current regardless of throttle pot specification or mechanical limits. This also works with most hall pedals.

If you installed a 2 wire pot then on the **user tab** select **configuration** setting **using 2 wire**.

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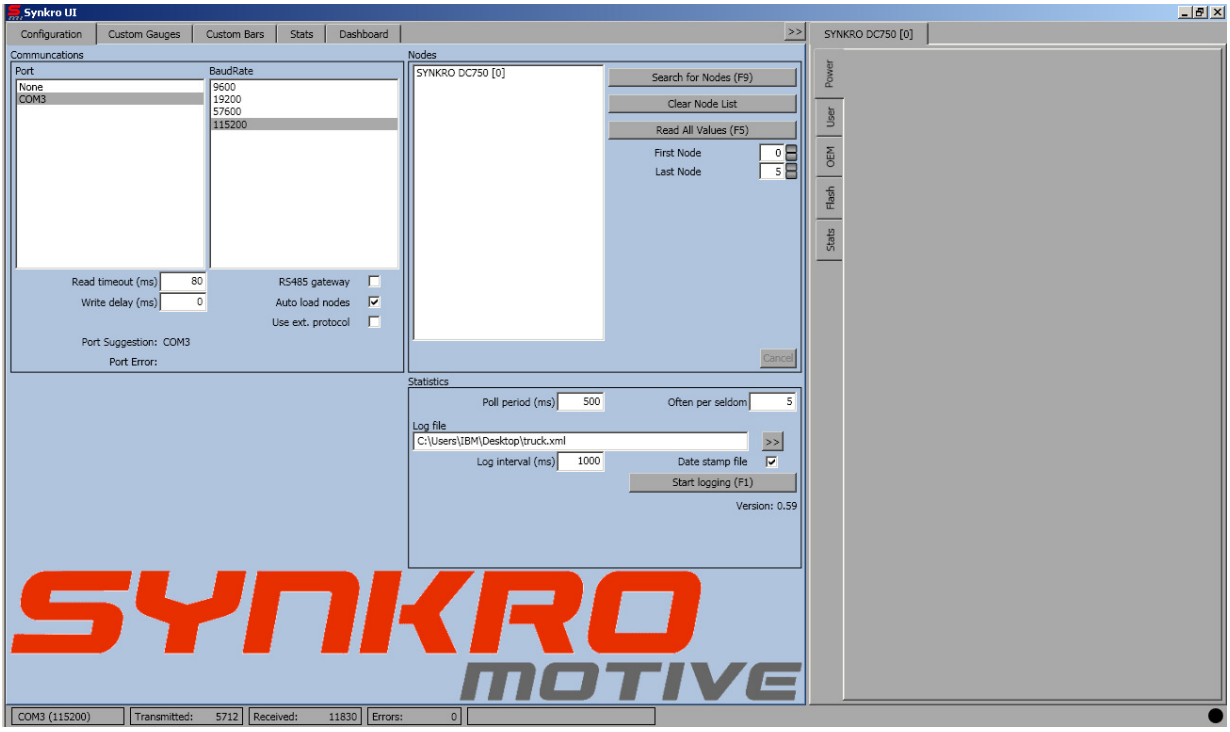
PC Data Logging

While connected to a PC, the DC750 can record data logs in real time. These data logs may be requested by Synkromotive in response to technical support queries.

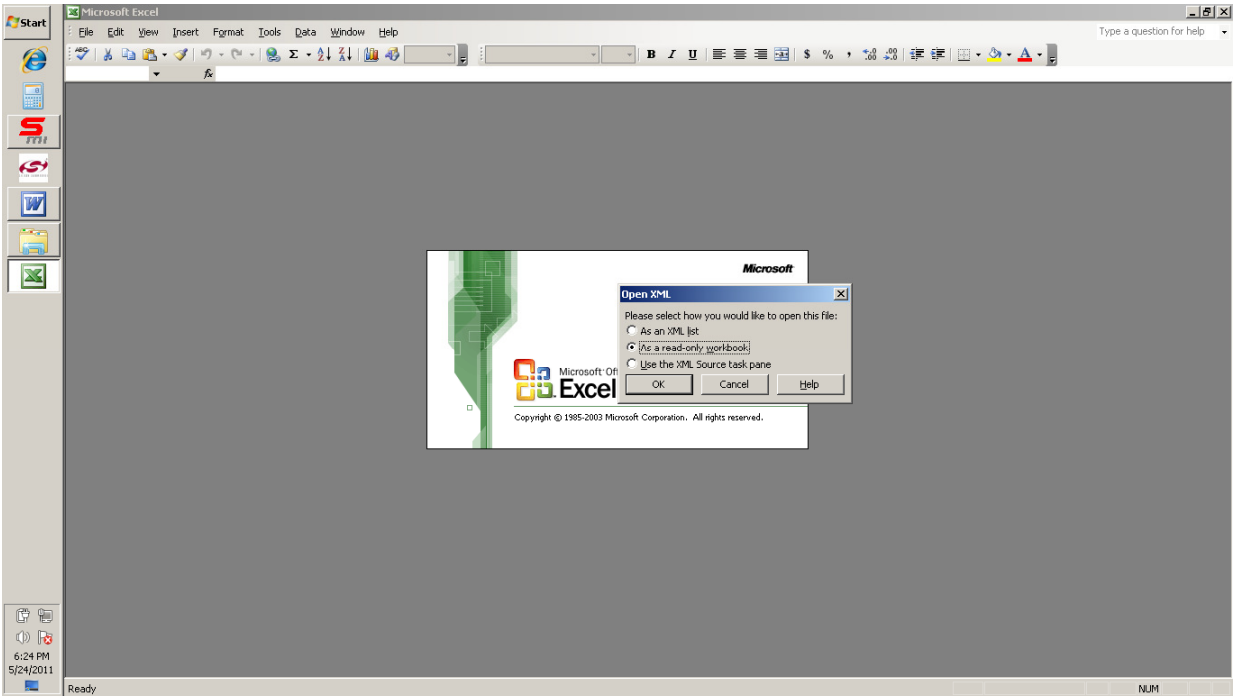
To start logging, make sure that the SMI software is running and navigate to the “Configuration” tab on the left hand side of the application.



Choose the desired frequency under the “Log Interval (ms)” entry box. Choose the save location and default log name under the “Log File” entry box. It is recommended that the “Date Stamp File” box is checked, as doing so will append the date to the desired log file name before it is saved, instead of overwriting any previous log file with the same name. To begin logging, click on “Start Logging (F1)” or press the F1 key, and to stop logging, click on “Stop Logging (F1)” or press the F1 key.

Connect to the laptop, Go to configuration tab and set the log folder to log to your desktop then the Click on “start logging”.

Data logs are in the XML format and may be read with any text editor however for simplicity should be compressed into a .zip file and e-mailed to Synkromotive for viewing. The XML log files can be also be opened in excel “as a read only workbook.”



DC750 Specifications

Input Voltage Range (Nominal): 24 volts to 180 volts

Peak Battery Voltage (During Charging): 195 volts

Maximum Motor Current: 750 amps

Maximum Loss: 1.5 KW

Switching Frequency: 20 kHz

Operational Safe Temperature Range: -10℃ to 40℃

Minimum Supply Voltage (Turn On): 11.7 volts

Off State Supply Current: 25 milliamps

Warranty

Synkromotive One (1) Month Limited Warranty

WARRANTY COVERAGE

Synkromotive, LLC's warranty obligations are limited to the terms set forth below: Synkromotive, LLC ("Synkromotive") warrants this hardware product against defects in materials and workmanship for a period of ONE (1) MONTH from the date of original retail purchase. If a defect exists, at its option Synkromotive will (1) repair the product at no charge, using new or refurbished replacement parts, (2) exchange the product with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the original product, or (3) refund the purchase price of the product. A replacement product/part assumes the remaining warranty of the original product or thirty (30) days from the date of replacement or repair, whichever provides longer coverage for you. When a product or part is exchanged, any replacement item becomes your property and the replaced item becomes Synkromotive's property. When a refund is given, your product becomes Synkromotive's property.

OBTAINING WARRANTY SERVICE

To determine if your product is eligible for warranty service, contact your Synkromotive dealer with a description of the problem. When you contact the Synkromotive dealer, you may be asked to furnish your name, address, telephone number, and proof of the original purchase (receipt) containing a description of the product, purchase date, and the product serial number. If the problem is eligible to be covered under warranty, they will then provide you with a Return Goods Authorization ("RGA") number. Deliver the product, at your expense, to the address provided by your Synkromotive dealer. Be sure to pack the item well and to reference the RGA number both on the exterior of the box, as well as within the box. Be sure to also include contact information and a concise description of the problem to expedite troubleshooting. Before you deliver your product for warranty service it is your responsibility to keep a written record of the any product parameters. You will be responsible for restoring all such parameters prior to use. Data recovery is not included in the warranty service and Synkromotive is not responsible for data that may be lost or damaged during transit or a repair.

EXCLUSIONS AND LIMITATIONS

This warranty does not apply: (a) to damage caused by accident, abuse, misuse, misapplication, or non-Synkromotive products; (b) to damage caused by service performed by anyone who is not authorized by Synkromotive; (c) to a product or a part that has been modified without the written permission of Synkromotive; or (d) if any Synkromotive serial number has been removed or defaced

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